CHAPTER 3. ENGINEERING PRACTICES OF COAL ASH PLACEMENT

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3.1 FUNDAMENTALS OF SOILS ENGINEERING

Soils engineering or geotechnical engineering focuses on assessment of a site from an engineering standpoint to determine essentially what can be built there or how the site can be used. Geotechnical engineering also provides various engineering methods and practices used in the actual design and construction of skyscrapers, dams, roads, and airports as well as homes, industrial facilities, and commercial buildings. In this regard, it is necessary to first investigate the site to determine what types of soils and bedrock exist, and estimate the strengths and other relevant properties of the earthen materials in the underlying "strata" (consisting of underlying layers of specific rocks and soil types in various potential conditions) for construction purposes. Some soils ("weak" soils) and rock types (carbonates) are not suitable for construction without potentially expensive modification or additional design requirements in regard to foundations. Once the site has been assessed, engineers can look at a variety of means to allow for construction including alternative foundation designs and/or importing off-site soils or coal ash to serve as fill and/or construction materials. The American Society for Testing Materials (ASTM, Standard Guide for Design and Construction of Coal Ash Structural Fills, E2277-03, 2003) references applicable Laboratory Test Procedures and Design Methods.

3.2 COAL ASH AND EARTHEN MATERIALS

Earthen materials are widely variable in physical and chemical properties and "in-place" strata conditions. Soil engineering methods have been developed that can be applied to coal ash as shown by decades of academic evaluation and practical experience in the Commonwealth of Pennsylvania. For purposes of engineering, uniformly placed coal ash can be considered as an artificial "soil" type that is usually more uniform than a natural soil layer. Additional testing is needed if different coal types, sources or burning processes may have generated the coal ash being evaluated, and also in the event of visible changes in natural soil types. For example, some coal fired boilers segregate lighter "fly ash" from the heavier "bottom ash" that falls to the bottom of the combustion unit during the combustion process. The physical properties of the segregated ash differ because of the different sizes and shapes of fly ash as compared to bottom ash. Therefore, the DEP regulations differentiate between several potential beneficial uses of the coal fly ash and bottom ash in 25 Pa. Code §287.665 (other beneficial uses of coal ash) because of the different properties. The pH of the coal ash is less important for foundation engineering purposes than the other mechanical properties of the coal ash, but is considered in the design process for any given usage per good engineering practice.

3.3 COAL ASH CLASSIFICATION

In general, coal ashes can be classified into coal source types (bituminous or anthracite), coal ash source (segregated or unsegregated fly and bottom ash), coal ash "gradation" (classification based upon the sizes of the ash particles), and other coal ash properties such as pH (relative “acidity” or “alkalinity”) relevant to the proposed usage. Engineering methods to determine gradation generally classify a soil or coal ash by the percentages of particles that can pass through standardized sieve opening sizes via comparison to a USDA Soil Triangle Classification Chart (Fig. 3.1)**.** Coal ash generally contains approximately 60 to 70 percent silt, and 30 to 40 percent sand size particles depending on the characteristics of the fuel burned by the plant (see Table 7.4 in Chapter 7). The coal ash classification is normally that of a silt loam. Other nationally recognized standard test methods then determine the properties of the coal ash relevant to the proposed engineering use or project as further described below. Continued testing is required for both soils and coal ash to ensure that the materials remain consistent with any required engineering specifications or design assumptions. For example, weathered coal ash may have lost the cementing (“pozzolanic”) coal ash properties desired in some applications.

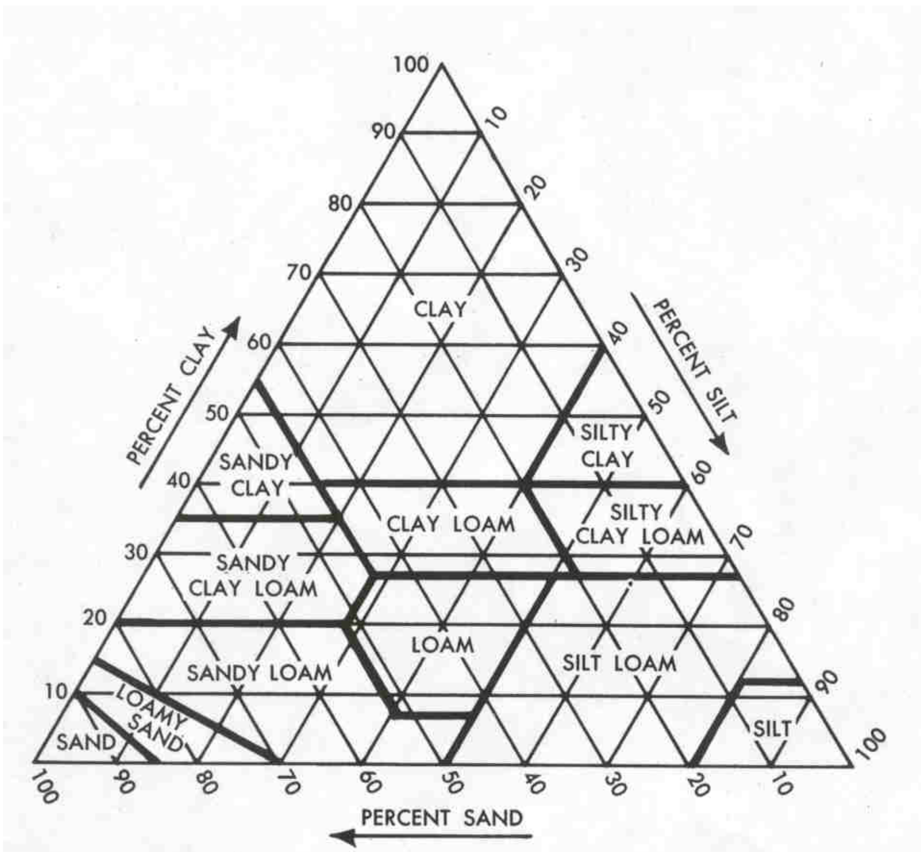

Figure 3.1. USDA Soil Triangle Classification Chart (The Asphalt Institute, 1978).

As mentioned in Chapters 1, 4, and 5, the DEP’s Regulations and Permit Conditions require regular monitoring of coal ash physical properties for conventional ash placement. DEP’s files contain a large amount of monitoring data, and periodically field checks are performed by DEP personnel, utilizing a Troxler nuclear moisture density gauge to determine accuracy and compliance of data submitted.

3.4 ENGINEERING TESTING AND EVALUATION

In coal ash monofills at both conventional ash disposal sites and demonstration ash sites, nationally recognized engineering standard tests are run and data is gathered. From this, an estimate of the ash's strength or bearing capacity can be made. The coal ash strength and bearing capacity sets the upper limit on potential building types, and other future uses.

Initially, if a certain ash is to be utilized, then a laboratory test must be run on the coal ash which is called a "Proctor Density Test" (either standard or most commonly the modified version). From this test, the theoretical Maximum Dry Density and the Optimum Moisture Content can be determined. Figure 3.2 illustrates a laboratory compaction test adapted from Bowles (1970).

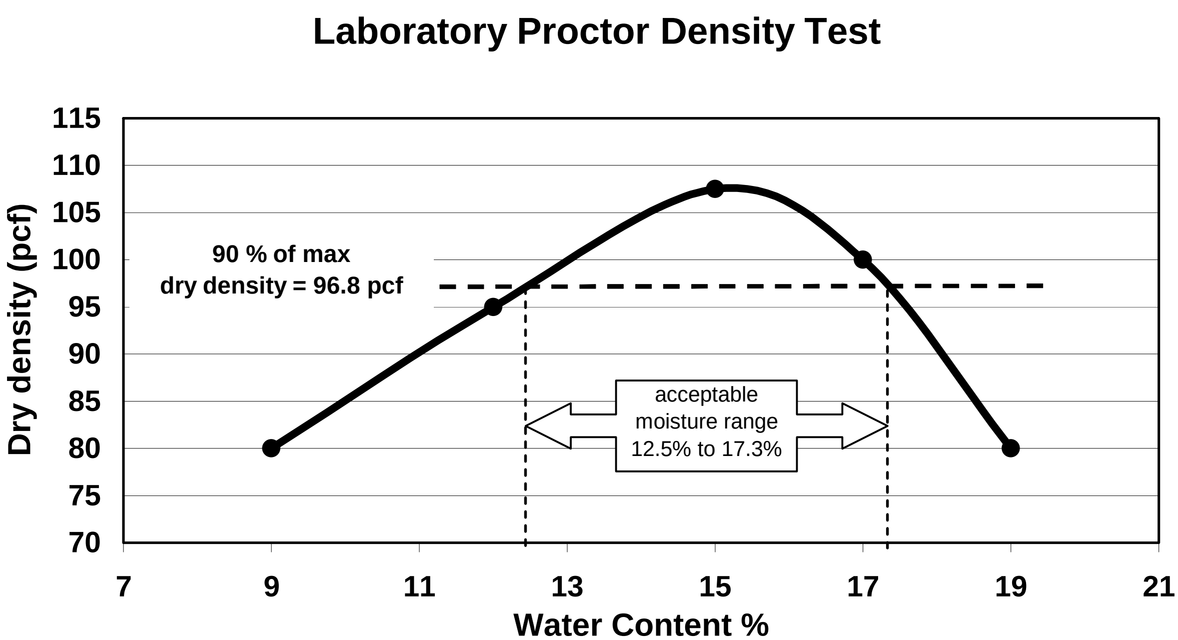

Figure 3.2. Typical display of compaction test data.

DEP requires that field compaction results achieve 90 percent of this laboratory maximum density of 107.5 pcf, in this example. By projecting a line through the curve at this point it is seen that, the acceptable moisture range needed in order to achieve the required compaction in the field is between 12.5 and 17.3 percent for the example in Figure 3.2. Therefore, the moisture content of the ash can be adjusted in order to place it on site within this moisture range**.** These numbers can then be used to ensure that the material is brought to the placement site at a moisture content which will allow adequate on-site compaction. In short, the test method usually shows a narrow range of density and optimum moisture for coal ash that has the desired engineering qualities for the proposed usage of the material**,** however the results can be different for fly ash and bottom ash. As can be seen on Figures 3.3a and 3.3b the maximum dry density was 75.9 lbs/cu.ft. for fly ash and 105.0 lbs/cu.ft. for bottom ash at the NEPCO site**.**

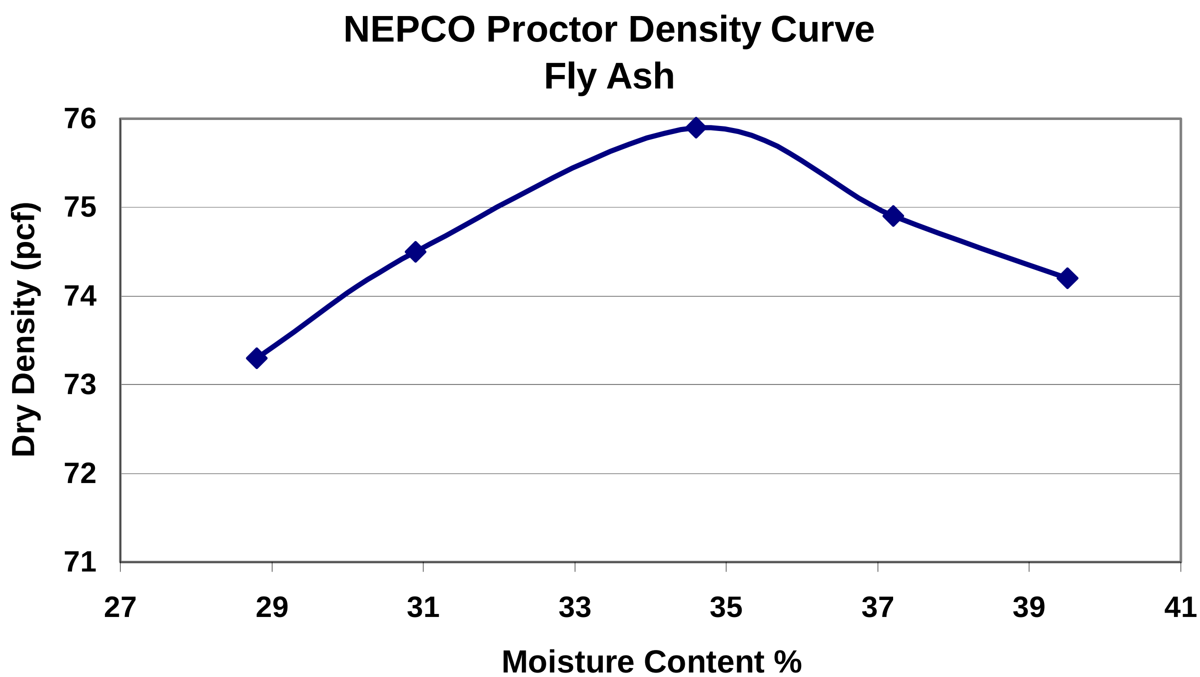

Figure 3.3(a). Plot of Proctor Density lab test results.

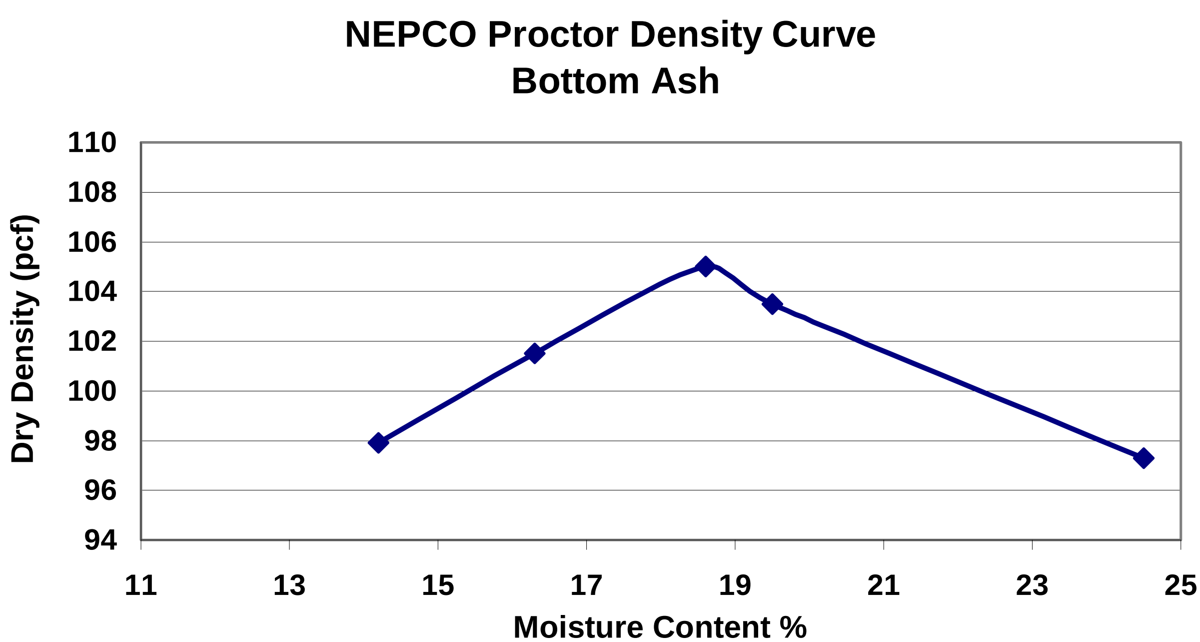

Figure 3.3b. Plot of Proctor Density lab test results.

An analysis of the maximum density, optimum moisture content, and field compaction test results for fly/bottom ash for four different ashes over time (Figs. 3.4a and 3.4b) indicates the maximum dry density varies from approximately 70 lbs/cu.ft. to 105 lbs./cu.ft. (mean value of 85 pcf), the optimum moisture content varies from approximately 16% to 38%, (mean value of 25%) (Fig. 3.4c). Field compaction tests reveal that compaction percentages are almost always 90% or higher. Other engineering properties can often then be correlated to the same maximum range of dry density, compaction and optimum moisture due to the uniformity of the coal ash materials.

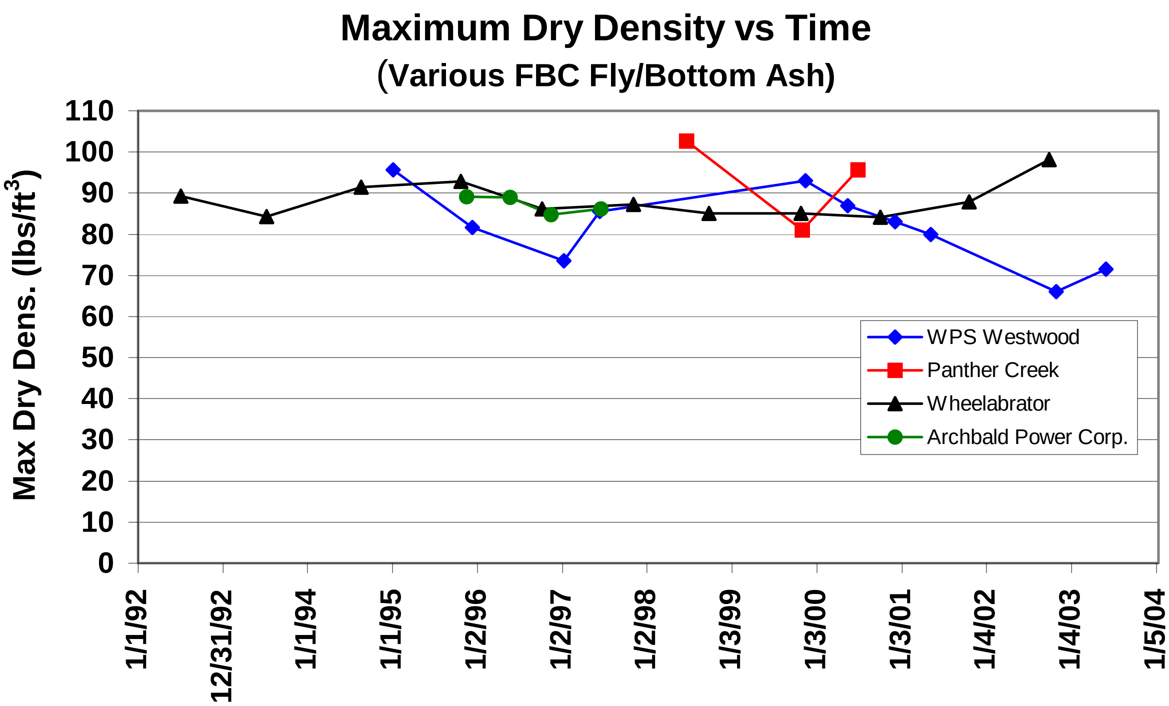

Figure 3.4(a). Plot of Maximum Dry Density.

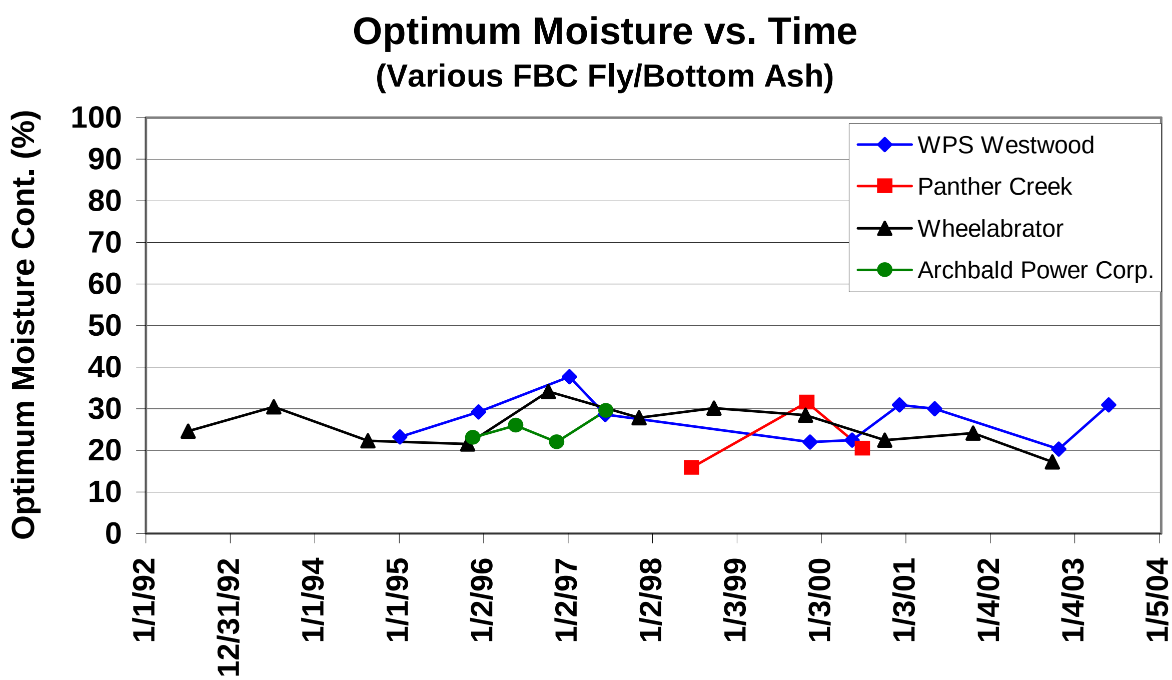

Figure 3.4(b). Plot of Optimum Moisture Content.

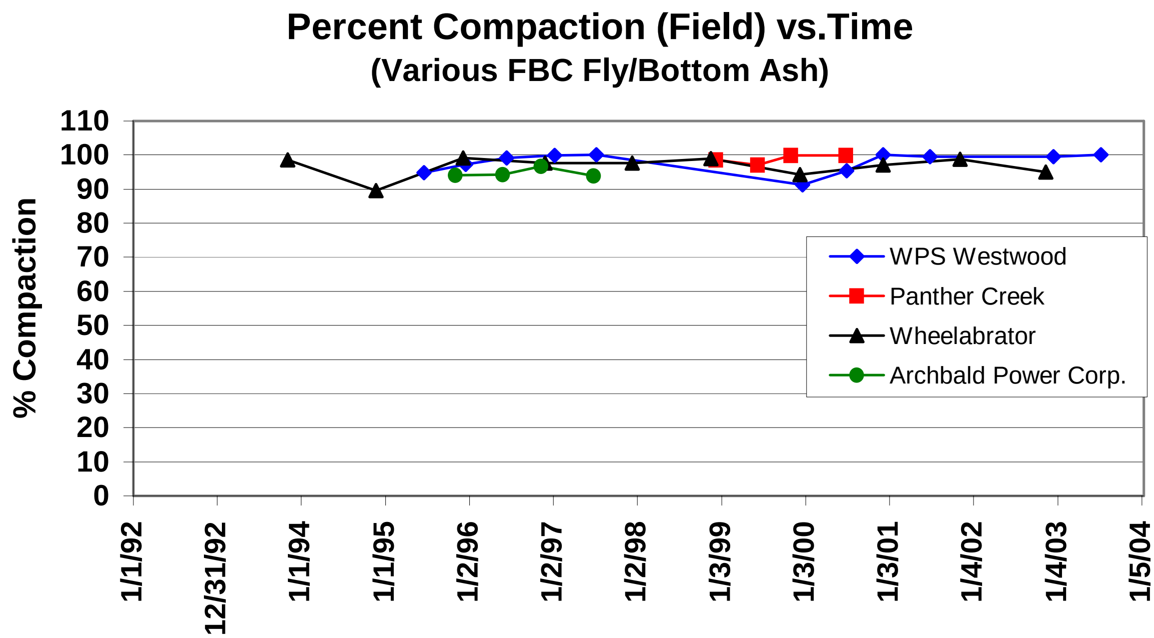

Figure 3.4(c). Field compaction tests of ash from various ash sources.

3.4.1. Compaction

The maximum dry density is that point where there is little potential for additional compaction. Therefore, long-term settlement of the coal ash is minimized if the coal ash is already near or at maximum density. Minimizing settlement avoids potential stresses on future buildings or other structures that might require eventual repairs.

3.4.2 Permeability

When coal ash is used as a construction material for sub-base at a coal ash landfill, the coal ash can be tested for permeability at different densities and moisture contents to determine a range where the desired landfill sub-base permeability requirements are met (see 25 Pa. Code §288.533(b)(ii)). By correlating the permeability to the coal ash density, optimum moisture content, and compaction, the engineer can reduce potential additional testing costs because the simpler and less expensive Troxler nuclear moisture density gauge tests can then be used to verify whether the material meets the permeability requirement.

3.4.3 Slope Stability

The "internal angle of friction" of the coal ash is obtained by testing at the proposed moisture content, density and compaction. The internal angle of friction sets a limitation for potential stable slopes of coal ash or other materials for purposes of retaining adequate stability. This can be an important consideration for non-reclamation projects.

After the ash is spread and compacted, field density tests can be performed with a nuclear densometer or other test method to determine or verify that the ash fill is meeting the 90% requirement. Results of these tests are summarized in a report from a certified testing laboratory. (see Table 3.1)

Table 3.1. Field Density Test Data at Panther Creek Energy.

Date	Optimum Moisture	Maximum Dry Density	Percent Compaction (field)
12/10/98			98.5
6/08/99			97
11/02/99	31.6	81	99.8
6/27/00			99.8

Occasionally direct readings are taken with a hand held pocket penetrometer (Sowers and Sowers, 1970), which gives a rough estimate of the bearing capacity of the material at the surface (e.g. in tons/square foot). This type of testing is primarily useful as a spot check for the surface layer of the placed ash. It must be supplemented with the Troxler nuclear moisture density gauge or other test methods giving results that are accurate for below the exposed surface of the coal ash.

Finally, in some cases, and for the demonstration permit sites, Soil Boring Tests are performed which utilize a split-spoon for sampling at depth intervals (usually 5 feet) and Standard Penetration Tests (U.S. Department of the Interior, Bureau of Reclamation, 1974) are performed at these same intervals which measure the number of times (i.e. the blow count) it takes to drive the spoon through a specified vertical interval with a standard weight hammer and drop distance on the drill rig (i.e. the "blow"), (ASTM Standard Penetration Test – ASTM D 1586-2003). From these numbers, the engineer can use technical literature (Tschebotarioff, 1974) in order to "ball park" estimate the "in-place" bearing capacity of the material at depth and can make recommendations as to design of footing foundations for structures, etc. (Table 3.2a and Table 3.2b and Table 3.3 Soil Boring Logs, and Figures 3.5 and 3.6 Location Maps). The two locations of the split-spoon sampling tests (TB-1 and TB-2) are shown on Figure 3.5 and the bearing capacity test locations which are identified as "x" on Figure 3.5 are quantified in Table 3.6. The Standard Penetration Test is a "qualitative" test method with potential for field errors that should not be used for any critical design without cross-checking by means of a different "quantitative" (more numerically precise and accurate) test method such as a plate loading test. While this is a widely used test method, there is no generally accepted conversion between "blow counts" (i.e. "N" value for the number of blows per foot of penetration) to bearing capacity for a soil although some technical sources have provided tables correlating the "blows per foot" for different soil classification (sand, silt, clay) and/or cohesionless versus cohesive soils for relative density (loose, medium, dense, very dense) and/or consistency (very soft, soft, firm, stiff, very stiff, hard). Other sources have provided empirical equations for estimating maximum allowable bearing capacity which may be utilized in less critical design situations. The available Standard Penetration Test data from the demonstration projects shows the uniformity of the placed coal ash whereas natural soils tend to increase in density and compaction the deeper the strata is located under the surface level. It is interesting to note that the laboratory "California Bearing Ratio" test (CBR) is based upon similar logic and is often used to design pavements (The Asphalt Institute, 1978).

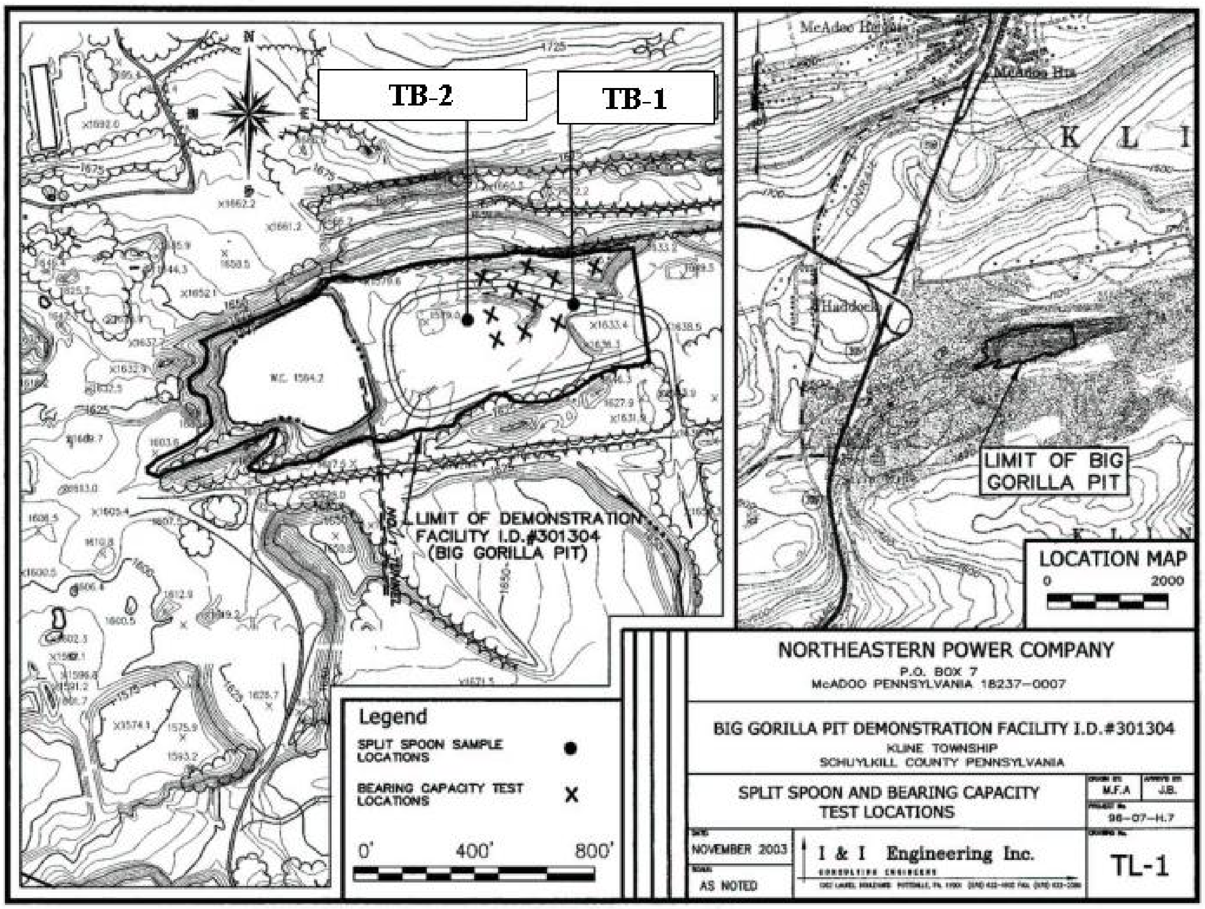

Figure 3.5. Map of NEPCO site showing Big Gorilla Pit.

Table 3.2(a). Soil boring logs from NEPCO site TB-1.

	Depth (ft) From-To	Sample No.	Recovery	Recovery	Blows / 6"	Blows / 6"	Blows / 6"	Blows / 6"
			Feet	%	0/6	6/12	12/18	18/24
7/16/2003	0-2	S-1	1.42	70.8	9	22	21	18
	5-7	S-2	0.58	29.2	2	2	1	2
	10-12	S-3	1.17	58.3	1	2	2	5
	15-17	S-4	0.67	33.3	8	7	4	3
	20-22	S-5	1.50	75.0	4	5	2	2
	25-27	S-6	1.25	62.5	8	11	10	9
	30-32	S-7	1.75	87.5	2	5	4	3
	35-37	S-8	1.42	70.8	6	6	2	2
7/17/2003	40-42	S-9	0.83	41.7	10	11	10	10
	45-47	S-10	1.25	62.5	10	11	7	11
	50-52	S-11	0.92	45.8	11	13	12	18
	55-57	S-12	1.25	62.5	18	13	18	21
	60-62	S-13	1.08	54.2	19	23	21	21
	65-67	S-14	1.00	50.0	18	14	18	16
	70-72	S-15	0.75	37.5	19	22	17	17
	75-77	S-16	0.83	41.7	10	12	13	15
	80-82	S-17	1.25	62.5	11	13	12	12
	85-87	S-18	1.42	70.8	7	8	8	12
	90-92	S-19	1.42	70.8	6	6	13	21
	92-94	S-20	1.00	50.0	16	23	19	20

Table 3.2(b). Test boring logs from NEPCO site TB-2.

	Depth (ft) From-To	Sample No.	Recovery	Recovery	Blows / 6"	Blows / 6"	Blows / 6"	Blows / 6"
			Feet	%	0/6	6/12	12/18	18/24
7/18/2003	0-2	S-1	1.67	83.3	7	9	10	14
	5-7	S-2	0.58	29.2	4	3	3	3
	10-12	S-3	1.00	50.0	2	1	1	2
	15-17	S-4	1.67	83.3	4	5	4	6
	20-22	S-5	1.58	79.2	6	3	2	2
	25-27	S-6	1.33	66.7	2	1	1	2
	30-32	S-7	1.25	62.5	4	3	1	5
	35-37	S-8	1.67	83.3	3	3	4	3
	40-42	S-9	0.75	37.5	11	6	8	6
	45-47	S-10	1.42	70.8	5	2	1	4
	50-52	S-11	1.83	91.7	3	1	1	2
	63-65	S-12	1.67	83.3	1	1	1	1
	65-67	S-13	1.83	91.7	1	1	1	1
	70-72	S-14	1.92	95.8	1	*	*	*
	84-87.5	S-15	2.25	64.3	*	*	*	*
	90-92	S-16	2.00	100.0	1	1	*	*
	100-102	S-17	1.92	95.8	2	2	2	2
	105-107	S-18	2.00	100.0	3	3	4	4

3.5 CONVENTIONAL ASH PLACEMENT

The disposal of coal ash in Pennsylvania is regulated under the Commonwealth's Residual Waste Regulations (25 Pa. Code Chapters 287 - 299). Permits are required to build, operate, expand, and close coal ash landfills and surface disposal impoundments. Permitted facilities must have an operating plan that contains procedures for the inspection and monitoring of incoming ash, the placement and compaction of the ash, the placement of cover materials and revegetation.

Although new coal ash disposal facilities are subject to the same design and operating standards as all other residual waste disposal facilities in Pennsylvania, the regulations contain specific standards and criteria addressing the beneficial use of coal ash.

In 1986, the Pennsylvania Solid Waste Management Act was amended to exclude coal ash that is beneficially used from the definition of "solid waste." Specifically, the definition excludes "fly ash, bottom ash or boiler slag resulting from the combustion of coal, that is or has been beneficially used, reused, or reclaimed for a commercial, industrial or governmental purpose".

The Act also gave the DEP the authority to establish standards and criteria for the beneficial use of coal ash. The amendment was subsequently implemented through the residual waste regulations. Provisions for the Beneficial Use of Coal Ash are found in 25 Pa. Code Section 287.661-666.

The regulations contain specific standards and criteria for three general categories of use:

- Structural Fill
- Soil Substitute and Amendment, and
- Mine Reclamation

The beneficial use of coal ash as structural fill is addressed in Chapter 287.661. The regulations require prior notification and submission of information on ash quality and site conditions for proposed structural fill applications. The notice must also contain construction plans prepared by a registered professional engineer and landowner consent. Coal ash may be beneficially used as a structural fill, as long as the proposed site meets environmental siting restrictions (e.g., separation from streams, groundwater, wetlands, etc.), the ash is spread uniformly and compacted in layers not exceeding two feet, and covered with a minimum of twelve inches of soil. An Erosion and Sedimentation Control Plan must also be developed for the project and approved by the local Soil Conservation District.

The beneficial use of coal ash as soil substitute or soil additive is addressed in 25 Pa.Code Sections 287.662 to 287.664 and Chapter 10 of this book. The use of coal ash as a soil substitute or soil additive is important at mine sites which often lack suitable quantities of cover soils. However, coal ash can only be used for this purpose if the constituent loading rate does not exceed the loading rate that would cause a pollution incident. In addition, for the use as a liming agent (soil additive use) the coal ash must also have at least a 10% calcium carbonate equivalency.

Table 3.3 Soil Boring Logs from Knickerbocker Site.

Reading Anthracite Test Boring Report - Cell 5-1				
	Blows / 6"	**Blows / 6"**	**Blows / 6"**	**Blows / 6"**
Depth (ft) From-To	**0/6**	**6/12**	**12/18**	**18/24**
0-2	2	3	4	5
2-4	12	12	10	11
4-6	9	10	9	10
6-8	10	12	15	16
8-10	13	11	12	14
10-12	10	11	11	11
12-14	12	11	12	14
14-16	12	11	10	11
16-18	10	10	10	11
18-20	11	11	10	11
20-22	9	12	13	12
22-24	12	13	11	10
24-26	10	11	10	9
26-28	9	9	8	6
28-30	7	8	6	7
30-32	7	5	6	7
32-34	5	6	7	4
34-36	8	8	8	6
36-38	5	6	5	5
38-40	5	6	4	5
40-42	3	2	2	3
42-44	3	4	4	3
44-46	4	2	3	3
46-48	4	3	5	4
48-50	4	5	5	5
50-52	1	2	1	1
52-54	2	3	2	3
54-56	2	1	3	4
56-58	4	5	4	7
58-60	8	9	9	10

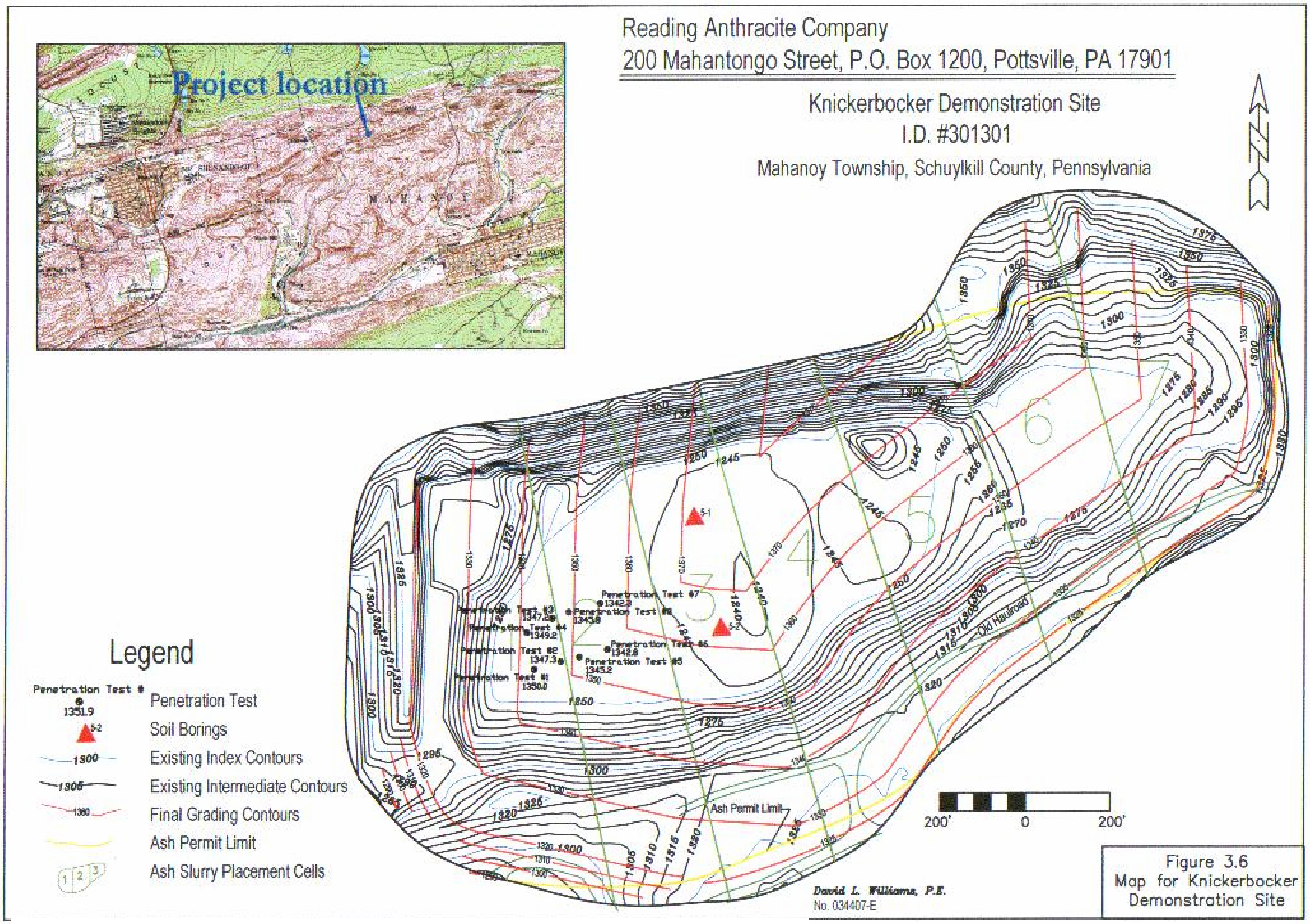

Figure 3.6. Map of Reading Anthracite Co., Knickerbocker Site.

The beneficial use of coal ash for mine reclamation is addressed in Sections 287.663-664 and subject to the requirements outlined in Table 3.4 Coal Ash Special Conditions. Coal ash may be beneficially used at active coal mine sites and abandoned mine sites to improve water quality or prevent degradation. In addition, coal ash is capable of eliminating public health and safety hazards at mine sites. Basically, the ash must be placed in allowable areas, spread and compacted in two foot lifts, covered with four feet of suitable material and graded to a 3% minimum final slope. On-site field densities are required during construction of the fill as mentioned in Section 3.4 to ensure a controlled, engineered fill.

Table 3.4. Key Items of Coal Ash Special Conditions used in DEP Permits.

KEY ITEMS OF COAL ASH SPECIAL CONDITIONS

- Grade the disposal area to create a stable base.
- Keep the coal ash disposal area free of standing, running, or impounded water at all times.
- All coal ash must be within the acceptable moisture content range in order to achieve a minimum compaction of 90% of the maximum dry density.
- Coal ash is not to be deposited within eight feet of any coal outcrop, vein or seam, pit floor, high wall, low wall or highest regional groundwater elevation.
- Complete chemical analysis and leachate analysis of the coal ash shall be conducted on a semiannual basis.
- Modified Proctor or Standard Proctor tests of each separate source of coal ash to be disposed shall be conducted on a semiannual basis, to determine the optimum moisture content and the acceptable moisture range needed to achieve a minimum compaction of 90% of the maximum dry density as determined by the Modified Proctor Test or 95% of the maximum dry density as determined by the Standard Proctor Test.
- Approved monitoring points shall be analyzed on a quarterly basis for Coal Ash Groundwater Quality Parameters.
- The final cover layer on the coal ash disposal area shall be a minimum of four feet.
- Field density tests (minimum of one test per acre of active coal ash disposal areas) shall be conducted to insure that proper field compaction is being achieved within the disposal area.
- All coal ash conveyed or hauled to the coal ash disposal area must be spread and compacted in lifts of two feet or less.

Finally, the regulations address a variety of uses that are deemed to be beneficial and do not require a permit from DEP as long as the requirements accompanying the specified use are met. Uses in this section include the replacement of cement in concrete, the use of bottom ash for anti-skid and construction aggregate (Fig. 3.7), and the use of fly ash as a stabilized product.

3.6 STABILIZATION OF FLY ASH WITH LIME OR CEMENT

Fly ash stabilized with lime or cement can be beneficially used to safely and economically replace conventional materials such as soils and aggregates in many construction applications. For example, PPL Generation, LLC developed a lime-stabilized fly ash product which consists of moisture-conditioned fly ash from PPL's pulverized coal-fired power plants that has been stabilized with a minimum of one percent hydrated lime. This has been beneficially used to construct foundations for commercial/industrial buildings; embankments for highways and airport runways; athletic fields and recreational facilities; and many other applications requiring a compacted fill material. It is often preferred over natural soils due to its low unit weight, relatively high compressive strength, ease of handling, and availability in bulk quantities.

The beneficial use of fly ash as a stabilized product is authorized under 25 Pa. Code §287.665(b)(3) of the residual waste regulations. Specifically, the person or municipality proposing the use must give advance written notice to the DEP, the ash cannot be mixed with solid waste, and the use must result in a demonstrated reduction of the potential of the coal ash to leach constituents into the environment.

PPL conducted studies on its fly ash documenting that the addition of a minimum of one percent hydrated lime results in a significant improvement in leachate quality. Representative samples of fly ash were split and amended with increasing amounts of hydrated lime, in one-half percent increments. Samples were extracted using the Synthetic Precipitation Leaching Procedure (SPLP) for leachate analysis (USEPA, 1998). The effect of lime addition on the leachability of minor and trace constituents in fly ash is shown in Figures 3.8 and 3.9.

The concentration of a few constituents, such as barium and selenium, increased at higher lime additions. However, concentrations are well within limits that the DEP has established as acceptable for mine reclamation and placement in natural attenuation landfills.

Since fly ash is a pozzolan, the addition of hydrated lime also improves the physical properties of the material making it more attractive than traditional soil-based fill materials. Pozzolans are siliceous and aluminous materials which, when mixed with lime and water, form cementitious compounds at ordinary temperatures. Figure 3.10 shows that the long-term unconfined compressive strength of the material (i.e. lime added to fly ash) is about twice that of unstabilized fly ash, and four times greater than ordinary soils.

Figure 3.7. Coal ash conveyor at left of photo delivers ash from Gilberton Power Company FBC plant to mineral processing equipment shown in center of photo to produce an aggregate which meets PA Department of Transportation specifications.

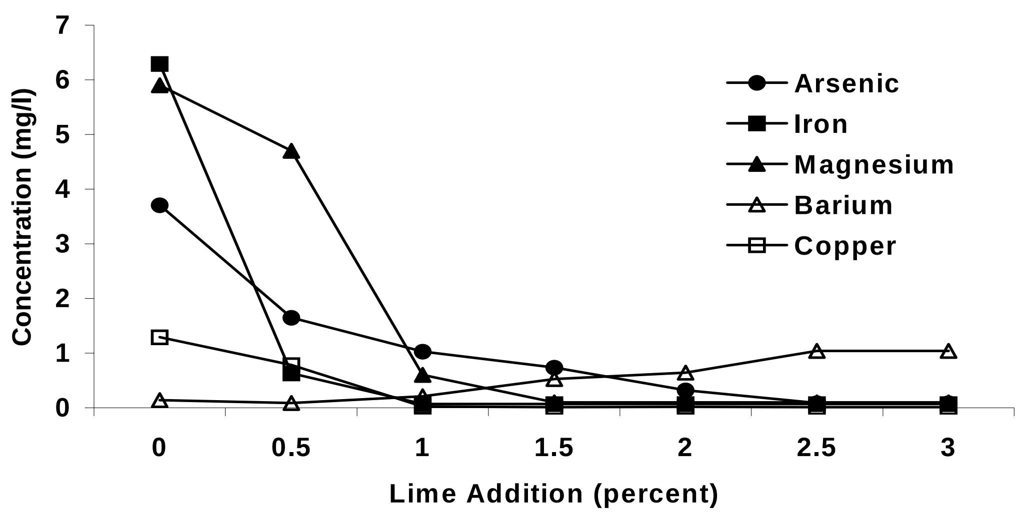

Figure 3.8. Effect of Lime addition on leachability of minor constituents and trace constituents.

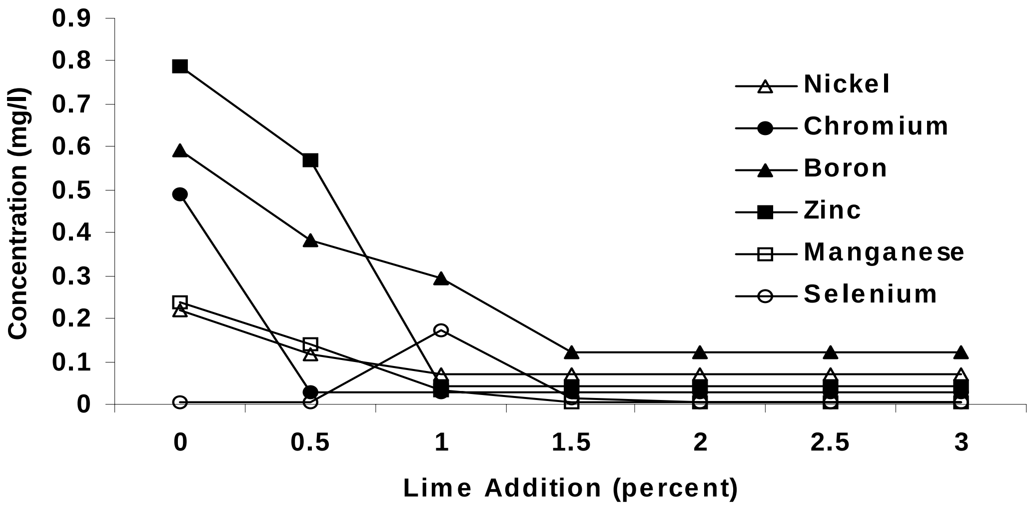

Figure 3.9. Effect of lime addition on leachability of minor constituents and trace constituents.

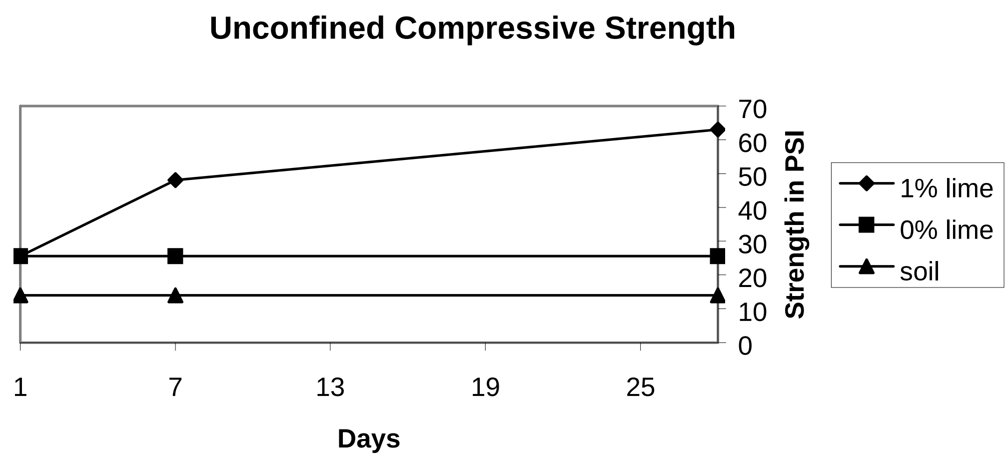

Figure 3.10. Effect of lime addition on compressive strength.

Table 3.5 compares other physical properties to unstabilized fly ash and conventional backfill materials. The loose and compacted unit weights are significantly lower than soil and clay, which is attractive in most fill applications where lighter materials are desired. The California Bearing Ratio (CBR) is a test used to estimate the bearing value of sub-bases and sub-grades. The CBR of coal ash is also significantly better than soil. Despite the formation of cementitious materials, it is still free draining. Permeability tests show that it has a hydraulic conductivity on the order of 10^{-5} cm/sec., comparable to fine-grained sand/silt.

Table 3.5. Comparison of physical properties of coal ash, sand and clay.

	Loose Unit Weight (pcf)	Compacted Unit Weight (pcf)	CBR (%)	Hydraulic Conductivity (cm/sec)
0 % Lime (ash)	45.3	88.5	0.6	3.5 E-05
1 % Lime (ash)	45.4	87.5	98	3.9 E-05
Sand	90	120	30	1.0 E-03 - E-05
Clay	75	105	5	<1.0 E-07

3.7 ENGINEERING PROPERTIES/ANALYSIS OF DATA

Analysis of the field density tests taken at conventional ash disposal sites has shown that their compaction consistently meets 90% or greater of the modified proctor densities with minimal compactive effort (i.e. dozers, trucks, etc) without the need for the usual steel drum, rubber tire, or sheeps foot roller equipment**.** This means that use of this extra equipment and labor are not routinely needed to achieve the required compaction and density for most sites. There may be some sites, however where compaction equipment may be needed.

At the demonstration permit sites, the soil penetrometer results consistently met or exceeded 3.0 tons/square foot (tsf) and commonly **"**maxed out**"** on the penetrometer gauge at 5.0 tsf, which more than satisfies the accepted minimum standard of 2.0 tsf listed in the permit. Available data from other test methods were compared to the penetrometer test results, and appear to support the high bearing capacities. The penetration results on the soil boring logs showed a sufficient value of "Blows/Foot" to adequately support a spread footing foundation at a design parameter of 2.0 tsf. Other test data from Scheetz (2001), shown in Table 3.6 below also support the high bearing capacity estimates.

Table 3.6. Bearing capacity results for NEPCO.

Plate Loading Test Results for Bearing Capacity at NEPCO						
Test #	0-6	6-12	12-18	18-24	Bearing Capacity	Location
1	15	53	50/2"		4,000 PSF +	see Figure 3.5
2	13	50/5"			4,000 PSF +	see Figure 3.5
3	15	43	50/4"		4,000 PSF +	see Figure 3.5
4	16	51	50/2"		4,000 PSF +	see Figure 3.5
5	17	59	50/2"		4,000 PSF +	see Figure 3.5
6	16	50/4"			4,000 PSF +	see Figure 3.5
7	15	50/5"			4,000 PSF +	see Figure 3.5
8	18	53	50/1"		4,000 PSF +	see Figure 3.5
9	14	48	50/2"		4,000 PSF +	see Figure 3.5
10	13	47	50/3"		4,000 PSF +	see Figure 3.5

In summary, the ash fills, whether at conventional or demonstration sites are more than suitable for construction purposes for residential or commercial buildings, roads, and most other engineering applications, with perhaps the exception of “super-structures” such as heavy bridges or tall buildings, but even these uses could be investigated on a case by case basis.

3.8 INNOVATIVE ASH PLACEMENT PROJECTS

Ash has been utilized in other cases either with or without additives such as cement or cement kiln dust in a slurry form to fill in mine voids, narrow crop falls, etc. where equipment access is a problem.

Flowable fill is defined by the American Concrete Institute Committee as "controlled low-strength material" (ACI Committee 229). Flowable fill is produced by mixing fly ash and a small amount of cement, hydrated lime or other binder material with water to a flowable consistency. Since fly ash is a pozzolan, it reacts with calcium hydroxide and water to form cementitous compounds. Flowable fill is virtually self-leveling with the consistency of pancake batter. It can be placed by pouring or pumping at a high slump (7 to 10 inches) and does not require vibration for consolidation. As a slurry, the material flows into place, filling small voids and uneven spaces. The mixture sets-up and hardens in a relatively short period of time and develops strengths similar to or greater than that of surrounding soils.

The use of a stabilized fly ash flowable fill to reclaim inaccessible mine openings was successfully demonstrated in November, 1993 at a vertical mine opening near Harwood, Pennsylvania (Mackow and Van Ness, 1994). The opening was located close to a ballfield and despite the presence of hazardous mine subsidence warning signs, there was evidence that children played near, and perhaps even in the mine opening. The filling operation took a total of five days and 500 cubic yards of flowable fill to plug the entrance of the mine opening. The flowable fill mix consisted of 2.5% hydrated lime, moisture-conditioned fly ash from PPL's Montour Steam Electric Station and water.

PPL has also partnered with the DEP to reclaim some "crop falls" in the anthracite coal fields. Crop falls occur where steeply pitching anthracite coal seams outcrop at the surface. Underground mining progressed up the rise in the coal to near the surface. After years of weathering the coal at the outcrop "fell" into the underground mine sometimes to a depth of 600-feet. Crop falls can extend for miles along the side of the mountains. Lime-stabilized fly ash from Montour Station was used as bulk fill in these projects

DEP has found these types of uses to be successful and continues to look at other possible uses within the same realm. Please note that the use of non-coal ash “waste” additives may require some form of explicit DEP approval as not all sources of cement kiln dust (CKD) or other waste additives may have been approved for the particular type of potential beneficial use involved. This is described in more detail in Chapter 6. Portland cement is not a waste additive and does not require DEP approval.